irradiation, there is a problem that a long time is required until the bridge reaction of the precursor ends. For example, it takes about 30 minutes to 1 hour until the bridge reaction of the precursor ends.

BRIEF SUMMARY OF THE INVENTION

A method of manufacturing a semiconductor device comprises:

preparing a substrate to be treated; and

forming an insulation film above the substrate, which includes applying an insulation film raw material above the substrate, the insulation film raw material including a substance or a precursor of the substance, the insulation film comprising the substance, curing the insulation film raw material by irradiating an electron beam on the substrate while heating the substrate in a reactor chamber, changing at least one of parameter selected from the group consisting of pressure in the reactor chamber, temperature of the substrate, type of gas having the substrate exposed thereto, flow rate of gas introduced into the reactor chamber, position of the substrate, and quantity of electrons incident to the substrate per unit time when the electron beam is being irradiated on the substrate.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWING

FIGS. 1A - 1C show cross sectional views of a manufacturing process of a semiconductor device according to a first embodiment of the present

invention;

FIGS. 2A and 2B show schematic illustrations of an electron beam irradiation apparatus used in embodiments of the present invention;

FIG. 3 shows spectrum intensities obtained by a Fourier transform infrared-ray spectroscopy (FT-IR) of an insulation films formed by a process of the first embodiment and process A - C;

FIGS. 4A - 4C show cross sectional views of a manufacturing process of a semiconductor device according to a five embodiment of the present invention;

FIGS. 5A - 5C show cross sectional views of a manufacturing process of a semiconductor device according to a six and seventh embodiments of the present invention;

FIG. 6 shows a measurement result of fluorescence intensities emitted from Ar^+ laser irradiated portions of a polymethyl siloxane film;

FIG. 7 shows an example of relationship between an intensity of fluorescence emitted from a polymethyl siloxane film and a shrink rate of the polymethyl siloxane film;

FIG. 8 shows a schematic illustration of an electron beam irradiation apparatus used in the eleventh embodiment of the present invention;

FIGS. 9A - 9C show cross sectional views of a

manufacturing process of a semiconductor device according to a twelfth embodiment of the present invention; and

FIG. 10 shows thickness dependency of a quantity of energy absorbed in a polymethyl siloxane film.

DETAILED DESCRIPTION OF THE INVENTION

Hereinafter, a description will be given with respect to a method for forming a coat film using heat treatment and electron beam irradiation treatment that is a basis of the present embodiments described below. In the above process, a liquid-like raw material (vanish) obtained by dissolving a film material or its precursor in solvent is applied on a substrate, and then, the liquid-like raw material applied on the substrate is cured by using heat treatment and electron beam irradiation treatment. Two typical examples of sequences of the method for forming the coat film are shown below.

[Sequence 1]

Step 1: Coating

Step 2: Heat treatment plus electron beam irradiation treatment

[Sequence 2]

Step 1: Coating

Step 2: Heat treatment plus an electron beam irradiation process

Step 3: Heat treatment